show a beneficial effect of any pharmacologic treatment of human spinal cord injury.

This work is encouraging, but in the past few years, a methodical search for agents that counteract the known effects of ischemia has provided compounds with more specific actions than corticosteroids. These agents are under extensive investigation using in vitro and in vivo trials in animals. The two types of compounds studied, NMDA-receptor antagonists and calpain inhibitors, act at different levels of the calcium cascade and may be synergistic. Other compounds have been developed to counteract the detrimental by-products of lipid peroxidation. Thus, specific components of the cell derangement can be pharmacologically manipulated.

In the future, patients with spinal cord injury may be treated like those with myocardial infarction. Once the injury has occurred, rapid transfer to a specialized center with experience in the medical and surgical treatment of spinal cord injury will be standard. As the molecular nature of spinal cord injury becomes unraveled, compounds (or combinations of compounds) will be designed to counteract different levels of the ischemic cascade. This may prove extremely valuable in preserving neurologic function.

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Ilizarov Method

THE ILIZAROV METHOD is a technique that helps provide alternative solutions to some difficult orthopedic problems, including pseudarthroses, bone defects, angular and rotatory deformities, osteomyelitis, the correction of limb-length inequalities, enlargement of bones, lengthening of amputation stumps, arthrodeses of joints, and the management of open and closed fractures. The method has introduced a set of biologic principles that have recently been recognized and that require continued study.

Ilizarov's concept of "tension stress" posits that gradual controlled distraction stimulates bone production and neogenesis. When a distraction force is applied, tissue fibers and cells become oriented in the same direction as the distraction vector. This is said to mimic the process of natural growth. Certain factors are required for optimal bone regeneration. Stable fixation is necessary and is obtained with the Ilizarov apparatus. The rate and rhythm of distraction are also critical. The maximal rate at which the body can regenerate tissue is 0.25 mm four times a day for an overall rate of 1 mm a day. Unlike the Wagner technique, this gentle distraction allows bone to form without the need for supplemental bone grafting and internal fixation.

The Ilizarov apparatus comprises wires, fixation bolts, rings, threaded rods, hinges, and plates. These components allow the construction of more than 800 assemblies. The apparatus from a biomechanical aspect is stiff for bending and torsion but less stiff for axial loading, which is thought to help promote osteogenesis.

Preoperative planning is essential to apply the Ilizarov method successfully. Careful attention to "safe zones" during wire insertion is important to prevent damage to vital nerves and blood vessels. Placing the involved muscle compartment on stretch during wire insertion minimizes contractures. Careful attention is also required to adjust the skin so that there is no tension on the skin-wire interface. The wires are then fixed and tension applied to rings that are in turn connected by threaded rods. The Ilizarov frame can be constructed in a way that will allow the appropriate correction of the deformity or lengthening.

For bone lengthening, a corticotomy is made in the metaphyseal region. This is a low-energy osteotomy that preserves the periosteal envelope. A latency period is required postoperatively before distraction. New bone should be seen within three to four weeks once the distraction has begun. Once the correct length is obtained or angular deformity corrected, the apparatus remains in place until the consolidation phase has been completed. During the postoperative period, frequent visits are often required to adjust or modify the assembly. Once the goal has been achieved, the apparatus is removed on an inpatient or outpatient basis.

Special postoperative considerations are important, especially because the apparatus may be in place for as long as a year. Pain tends to be mild to moderate, but its duration may make management a challenge. Intensive physical therapy and splinting techniques are used to prevent flexion contractures of the surrounding joints. Psychological support and family counseling are key elements to successful treatment.

Postoperative problems can include pin-track infections, premature or delayed consolidation, joint contractures, and pin breakage that may require replacement.

The Ilizarov method provides orthopedic surgeons with another tool to manage difficult problems. It is complex yet provides hope for some patients. Its use should be reserved for centers with extensive experience in pediatric or reconstructive orthopedics until more data are available regarding techniques, complications, and results.

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Update on the Diagnosis and Treatment of Scaphoid Fractures

THE SCAPHOID SERVES as an important mechanical link between the proximal and distal rows of carpal bones. Nonunion or malunion following its fracture allows malalignment of the carpal bones among themselves and against the radius. This predisposes to degenerative arthritis. Changes develop insidiously but predictably 10 to 20 years later. This accounts for the emphasis being placed on precise anatomic healing of the scaphoid. Only then can normal mechanics of the wrist be restored and late degenerative changes be avoided.

Because of the scaphoid's oblique orientation in the wrist in both the frontal and sagittal planes, routine wrist x-ray films may not always reveal a fracture line. Undiagnosed fractures are the most common cause of nonunion. When a fracture is suspected but initial radiographs are normal, placing the wrist in a cast for two weeks and repeating the examination and radiographs are indicated. If scaphoid tenderness persists but the radiographs remain normal, bone scanning using technetium Tc 99m will identify the occult fracture. For nondisplaced fractures, a thumb spica cast should be in place until tenderness has subsided and radiographic healing is evident. This usually takes 9 to 12 weeks. Orthopedists debate whether long-arm or short-arm casts should be used for nondisplaced scaphoid fractures; most would agree to at least several weeks of long-arm casting for a displaced fracture that has been successfully reduced by manipulation.

Because more than 1 mm of fracture displacement or any angular malalignment will predispose the wrist to degenerative changes, computed tomography oriented along the scaphoid's long axis is often useful to verify anatomic reduction. If anatomic alignment cannot be accomplished and maintained by closed means, then open reduction is necessary. Kirschner wire fixation has been used, but this requires a protective cast and has the risks of pin-track infection and wrist stiffness related to the prolonged immobilization. Internal fixation can be done with the Herbert screw, which is specifically designed for scaphoid fractures and nonunions. Rather than a conventional screw head, the trailing shaft supports threads that are more shallowly pitched than those on the leading shaft. Thus, the screw can be completely buried in the bone to avoid touching adjacent articular surfaces. More important, the pitch differential between the leading and trailing ends allows compression of the bone fragments as the device is inserted. Bone healing is not necessarily accelerated with the use of the screw, but the time of cast immobilization is lessened, reducing disability and the risk of wrist stiffness.

Despite adequate primary treatment, about 5% of scaphoid fractures fail to unite. This discouraging result is usually related to a disruption of the proximal fragment's blood supply at the time of injury. Even for scaphoid nonunions that are asymptomatic, further efforts should be directed at achieving union to avoid osteoarthritic changes several decades later. Electrical stimulation is not useful, and partial or total silicone replacement arthroplasty risks a foreign body synovitis from the debris particles generated. Autogenous bone grafting remains the treatment mainstay. The bone graft stimulates bone healing across the nonunion site. Also, a properly shaped graft restores the anatomic contour of the scaphoid. Here, as with acute fractures, a reconstructed scaphoid can be stabilized either with Kirschner wires and a cast or with the scaphoid screw. In patients who have residual pain with equivocal healing seen on plain radiographs, computed tomography again has proved a useful diagnostic and treatment guide.

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Open Reduction of Pelvic Fractures

TREATING PELVIC FRACTURES nonoperatively has been associated with poor long-term results in certain types of pelvic injuries. These injuries include displaced fractures of the acetabulum in which joint incongruity is produced by the injury, leading to a rapid, progressive, posttraumatic degenerative disease of the hip joint, and injuries to the pelvic ring between the acetabulum and the sacrum, causing either rotatory or vertical instability of the injured hemipelvis. Such instability may lead to nonunion of the fracture, unacceptable rotational deformity, or unacceptable shortening of the hemipelvis and limb. Indications for the nonoperative treatment of acetabular fractures include a fracture displacement of less than 3 mm, low anterior column or transverse type fractures, both column fractures with secondary congruence, and fracture with mild displacement in an elderly person. Fractures with displacement of 3 mm or more and high acetabular fractures are generally treated with open reduction and internal fixation. Fractures in elderly patients may qualify for open reduction and internal fixation because of their displacement or location. The operative procedure is a major one, however, and a better result may often be achieved by early nonoperative treatment followed by total hip arthroplasty if symptoms so warrant.

The techniques of open reduction and internal fixation of acetabular fractures are technologically complex and require a relatively long "learning curve." Common complications include heterotopic ossification, often treated with indomethacin, low-dose irradiation, or both, and degenerative arthritis due to the inability to restore anatomicity of the joint or damage to the articular cartilage caused by the initial injury.

Pelvic ring injuries require fixation when they are unstable. For a rotationally unstable injury with overriding or widening of the symphysis pubis but with intact posterior sacroiliac ligaments, an anterior symphysis plate or an anterior iliac crest external fixator will usually suffice. Vertically unstable fractures have both anterior and posterior disruption and require internal fixation if the vertical displacement of the hemipelvis is more than 1 cm. Posterior iliac crest fractures and disruptions of the sacroiliac joint can be fixed by using either plates or lag screws. Sacral fractures occasionally require the use of the cobra plate or sacral bars. Supplemental anterior fixation using an external fixator or a symphysis pubis plate increases the biomechanical stability of the fracture fixation.

Complications of open reduction and internal fixation of pelvic ring fractures include the possibility of spermatic cord injury with symphysis pubis plating, neurologic injury with overcompression of the neural foramina of the sacrum or with the anterior approach to the sacroiliac joint, and posterior wound breakdown, seen in approximately 26% of cases involving posterior surgical approaches to the sacroiliac joint. Newer techniques of internal fixation of both acetabular and pelvic ring fractures include the use of manipulation and traction for closed reduction, followed by lag screw percutaneous fixation under image intensification or computed tomography.

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